Science Arena Publications
Specialty Journal of Engineering and Applied Science
Available online at www.sciarena.com
2017, Vol, 3 (1): 20-31

The Impact of Addition of Agar Gum and Propylene Glycol Mono-stearate Emulsifier on the Qualitative and Physicochemical Properties of Sponge Cake

Mahvash Anvarinejad[1], Afshin Javadi[2]*
[1]Ph.D. Student of Food Science and Technology Engineering, Islamic Azad University, Mamaghan Branch, Iran.
[2]Associate Professor of Food Hygiene and Aquatic Animal Health, Biotechnology Research Center, Tabriz Branch, Islamic Azad University, Tabriz, Iran
* Corresponding Author

Abstract: *This study aimed to investigate the impact of guargum and propylene glycol mono-stearate (PGME) emulsifier on the physicochemical properties of sponge cake. Therefore, guar gum at levels of 0%, 0.3% and 0.5% and PGME emulsifier at 0% and 0.5% levels was added to the formulation. The treatments were examined in 3 replicates and the results obtained were analyzed by using one-way ANOVA and were compared using Duncan's multiple-range test at probability level (0.05>p). The results showed that the addition of guar and PGME led to increased cake specific volume. The results of the texture analysis of the samples indicated a lower hardness (firmness) in the sample containing gum agar (0.3%) and emulsifier (0%). The highest specific volume value of cake belonged to gum (0.5%) and emulsifier (0.5%). An increase in the level of gum agar and PGME emulsifier in the formulation of sponge cake resulted in an improvement in the amount of L component in the cake that can be attributed to the high water absorption capacity by gum and PGME emulsion. Based on the results, the highest sensory attributes score belonged to the sample containing 0.5% gum and 0.5% emulsifier. The addition of agar and PGME emulsifier improved water absorption, increased porosity and improved the texture in such a way that the measurement of texture properties of the cake by texture analyzer revealed that the addition of gum and emulsifiers will reduce the firmness of the cake over time.*

Keywords: *Sponge cake, agar gum, emulsifier, propylene glycol mono-stearate, organoleptic properties, physicochemical properties*

INTRODUCTION

1. Nowadays, most of the spoilage of the flour based products (such as cakes, cookies, and muffins), which are produced and delivered with a high content of moisture, is caused by microbial decomposition and molding; water activity is the main contributing factor for these two processes. If the water activity is lower than a limit, microorganisms are not able to grow and reproduce. Therefore, the best and most effective way to prevent microbial degradation and molding of high humidity products is to reduce water activity, including the use of different materials such as emulsifiers, absorbent materials and preservatives such as gums, reducing sugars, sorbitol, glycerin, propylene glycol, etc. In addition to the food spoilage resulting from microorganisms, going stale of some flour products like cakes, breads, etc. is also of particular importance. If flour based products

such as bread, cake, and products with sponge texture and humid kernel are stored at ambient temperature, the quality of this product will be gradually reduced and become stale. In general, the higher moisture content in fresh products, the more pronounced changes due to product staling (Galic K et al, 2009). By increasing the moisture content in the product, the emulsifier is able to slow down the product to become stale. A lot of research and studies have been done on the materials used to improve the smoothness of the kernel. For example, addition of this type of material to batter, say, cake increases its volume and produces low density products, and it also has a great influence on the structure of the gluten protein network. These materials make more resilient properties for the brain cake and moisture content in the product as well as soften the brain cake (Fathi M et al, 2011). Moisture products like cakes and bread become staler than those with low moisture like muffins. The shelf life of flour products depends on complex factors and conditions that make it difficult to extend the shelf-life of these products. To extend the shelf-life of these products requires access to full information and mastery of experts, technologists and researchers in the production and packaging process so as to able to produce these materials with high quality and durability and longer shelf life. In order to extend the shelf-life of the product, it is necessary to determine the factors that decrease the shelf-life. Therefore, this study aims to identify these factors and find some strategies to reduce them.

Theoretical foundations of the study

2. In general, cake is defined as a product that is made by formulation based on wheat flour, sugar, eggs, and liquids such as milk that fat may have been added to it (Cauvain SP et al, 2003). Like biscuits and muffins, the cake falls into the handful of food ingredients known as flour confectionary. In these products, the properties of the product are determined by batter ingredient (Cauvain SP et al, 2003). A sponge cake is considered to be a type of cake which is made from equal quantities of eggs, butter, sugar and flour. An increase in cake batter volume is an important point which should be considered while baking the cake because in comparison with egg whites, the use of whole eggs leads to less puffy cakes. The addition of Tartar cream, lemon juice and sugar to the cake mixture helps to form a sponge state and its stability (Peighambardoost, 2007). The main function of emulsifiers in making cake is to help increase the volume and improve the texture and structure, as well as the cutting quality and increased storage capacity (Korg N, 1977). Propylene glycol mono-stearate is a clear liquid with yellow-white flakes. It is a nearly odorless liquid with a mild sweet taste which is soluble in water. In addition, it can be served as an emulsion and stabilizer in the cake dough (Gerrard JA et al, 1998). The term hydrocolloid is commonly used to describe a group of water-soluble which their key function in food products is to control texture and organoleptic properties. Their specific role is to increase the viscosity and gel formation in the foodstuff (McKenna BM, 2003). Agar hydrocolloid used in this study is a dry extract of red algae from GELIDIUM species which is obtained from red seaweed of Rhodophyceae class and chemically classified as galactan sulphuric acid. It is a thin, clear or round, white to yellowish in color, tasteless and odorless (Fatemi, Hassan, 1999).

Literature Review

3. In a study, Maleki et al. examined the impact of adding four different hydrocolloids including guar, xanthan and carboxymethylcellulose CMC and hydroxypropyl methylcellulose HPMC in concentrations of 0.1, 0.5 and 0.1 weight-weight percentages (w/w %) based on flour on the microstructure and porosity of Barbary bread. For this purpose, the porosity was measured by the Image-pro plus program and the microscopic examination of the fresh cereal were performed by SEM machine. The results of the image analysis showed that the addition of hydrocolloids could make a more porous and crispy texture in the bread. Also, the results of an electron microscope indicated that the addition of hydrocolloids leads to formation of bread with more uniform and soft texture. These results confirm the improvement effect of hydrocolloids on the texture of fresh Barbary bread; although, it was found that the improvement effect holds true for all added hydrocolloids; it seems that CMC cellulose derivatives and HPMC are more effective in this regard (Maleki G et al, 2012). In another study by Pourfarzad et al., response surface methodology was used to examine the effect of improving gel component on the stickiness of Barbari bread dough and to optimize the gel formulation. The gel samples were prepared by adding sodium stearoyl lactylate (SSL), DATEM and propylene glycol ranging from 0 to 0.5 grams per 100 grams. The results indicated that the addition of all three components to the gel formula reduced the stickiness force. Although the addition of all three components decreased the stickiness distance, the square of sodium stearoyl lactylate and the interaction of interaction of the DATEM and propylene glycol significantly decreased it. Stickiness level was only affected by the square of sodium stearoyl lactylate and other components had no significant effect on this index. The models presented in this study had a high correlation coefficient that can be used to predict the studied properties. The optimization results along with the central composite design indicated that the least stickiness was obtained when the gel formula contains 100 g / 0.5 g sodium stearoyl lactylate, 100 g / 0.5 g DATEM and 100 g / 0.5 g propylene glycol (Pourfarzad A et al, 2011). Furthermore, Fathi et al. examined the effect of emulsifier gel prepared from Sodium stearoyl-*2*-lactylate (SSL), Distilled glycerol monostearate (DGMS), propylene glycol mono- stearate (PGMS), polysorbate 60 sorbitan monostearate (SMS) on the physical properties of cake dough and cake quality. Compared to the control group, both the rate of storage modulus (G 0) and loss modulus (G 00) containing the emulsion gel showed an increase. To measure the density of dough, the assessment of cake dough showed that the emulsifier gel decreased the density of batter (dough) from 0.95 for control to 0.85 grams per cubic meter. Furthermore, photomicrographs of cake batter using different emulsifier gels gave an indication of an increase in the number of air bubbles that were distributed equally. Compared to the control group, the batter is lighter and better air mixing. Among the emulsifier gels, the cake containing polysorbate 60 showed the maximum increase of specific volume and subsequently SSL, PGMS, HPMC and SMS gels led to an increase of specific volume (Fathi M et al, 2011). In a similar study, Arab Shirazi et al. investigated the increasing trend of egg with xanthan gum and hydroxy-propyl-methyl cellulose with SSL and GMS emulsions in sponge cake. In this study, xanthan and hydroxy-propyl-methyl cellulose were separately added and mixed with wheat flour emulsifiers. Then, the

rheological properties of the obtained batter were examined using Farinograph and Extensograph systems. Moreover, the cake was evaluated in relation to protein and moisture. The results of the Farinograd test indicated that the replacement of xanthan gum and hydroxy-propyl-methyl cellulose with eggs separately or in the presence of emulsifiers led to improved absorption of water, dough development time and dough resistance time. In addition, the results obtained from the extensograph showed that compared to the control group, the surface area under the curve, resistance to extensibility and dough resistance coefficient to extension in dough containing xanthan gum and hydroxy-propyl-methyl cellulose, as well as SSL and GMS emulsifiers were shown to be higher. Moreover, the results of chemical properties revealed that the moisture content of all treatments was increased and decreased compared to the control sample of the protein. The results also showed that the sponge cake contains both gums and cake containing gum together with an SSL emulsifier yielded samples of better quality compared with other samples (Arabshirazi Sh, 2011). Ashwini *et al.*, (Ashwini A et al, 2009) conducted research on the impact of hydrocolloids such as Gum arabic, guar, xanthan, carginan and hydroxy-propyl-methyl cellulose in combination with emulsion such as glycerol monostearate (GMS) and Sodium Sterol-2-Lactylate (SSL) on the rheological, microstructure properties as well as quality of egg-free cakes. The results indicated that the addition of guar to wheat flour in the presence of sodium stearoyl lactylate would increase peak viscosity; whereas in the presence of GMS all hydrocolloids excepting xanthan were increased. As the hydrocolloids are added, the backward index decreases. Addition of hydrocolloids to wheat flour in the presence of SSL and GMS increased cake batter viscosity without egg. Using HPMC along with GMS increased the quality score to the highest and consequently reduced the xanthan and carrageenum parameters. The addition of all hydrocolloids with SSL improved the overall quality of an egg-free cake, resulting in the highest improvement in HPMC (Ashwini A et al, 2009). The results of Garline reviews in 2008 regarding the interaction of emulsifier with amylose and its effect on cake quality showed that the qualitative and anti-staling properties of cakes containing emulsifiers with high complexity capacity are better than those with a low complexity capacity. The emulsifier was added to the formulation of the cake and its effects on the density of the batter, specific volume and cake texture were investigated. The results showed that the density of the batter was reduced and the specific volume was increased. Addition of emulsifiers also improves the chew-ability and cake appearance (Garlin GT, 2008). In his study on the effect of gums and emulsifiers on the quality of low-sugar cakes, Collarc (Collarc P, 2005) concluded that the addition of monoglyceride emulsifiers, sucrose esters, xanthan gums resulted in increase in batter viscosity and the final volume of cake and water activity and the staling volume of cake was decreased as well (Collarc P, 2005). In 2004, Walker examined the effect of sucrose fatty acid ester emulsifier on sponge cake. Sucrose esters have recently been expanded for food applications. This emulsion has a significant effect on the improvement of specific weight, volume and texture of sponge cake. In this study, sucrose esters with HLBs ranging from 6, 11 and 15and commercial emulsifiers of Mono- and diglycerides at levels of 1%, 2.5%, 4% of the flour weight were used. When added to the sucrose esters, the dry ingredients of the cake formulation in the powdery state will increase the cake volume and the desired texture will be obtained. Sucrose esters, recently approved for food use. They have been shown to affect batter specific gravity, cake volume, crumb firmness, and texture of sponge cakes. In this study, sucrose esters with hydrophil-lipophil balance values of 6, 11, and 15, and a commercial plastic or-monoidiglyceride emulsifier were tested at 1, 2.5, and 4% flour weight basis. When added in powder form to the dry ingredients, the sucrose esters increased volume and tenderness and produced a more desirable texture. When the same sucrose esters were hydrated before addition, resulting cake volumes averaged 20 to 160 cm^3 greater than when the sucrose ester was added in powder form (Walker CE, 2004).

Method and materials

4. Wheat flour at 81% extraction rate and a viscosity 1200 were purchased from one of the city's confectionery stores. Flour chemical ingredients were measured according to standard methods (Paul MN, 2000). Moisture content was determined using Avon method (16-44), the amount of ash using the base method (01-08), the amount of protein using the Caledon method (12-46) and gluten using the method approved (11-38).

The specifications of flour basis are given in Table 1.

Table 1. Characteristics of wheat flour

	Characteristics	Value
1	Moisture (% by weight)	10
2	Protein (% by weight)	10.5
3	Ash (% by weight)	0.2
4	Moist gluten (% by weight)	8.17

Other materials required for testing include powder baking, Ladan oil and vanilla were purchased from a store for raw materials of confectionery and Telavang freshly eggs were also prepared one day before the daily production of cakes and were kept in the refrigerator. Additionally, agar gum and propylene glycol mono-stearates with commercial name of Grindsted PGMS from Merck company (Germany), and dried milk and whey powder containing 35% of protein from Kalah Amol company were prepared. Due to their moisture absorbency, these materials were stored in packages that are completely impervious to the air.

Batter and Cake production: In order to prepare a cake batter, oil and powder, sugar were initially mixed with an electric mixer model (Electra EK-230M, Japan) at 128 rpm for 10 minutes for preparing a light cream containing air bubbles. Then the egg was added to it in 4 turns. Afterwards, all the powdered materials were sieved together and added to the batter in the next step until the batter became semi-smooth. Next, gum and emulsifier were added and finally, the water was added to make the batter smooth. 200 g of the prepared batter was poured into paper cups. Then the batter cakes were baked in a home-made oven (Asel model) at 170 ° C for 20 minutes. After cooling, in order to evaluate quantitative and qualitative properties, each sample of polyethylene bags was packed and stored at ambient temperature.

Table 2. Sponge cake formula for control group

	Essential material	Amount (percent)
1	Oil	57
2	Sugar	72
3	Egg	72
4	Flour	100
5	Baking powder	1.34
6	Milk powder	2
7	vanilla	0.5
8	Whey powder	4
9	Water	25

Volume measurement test: A piece of weighing cake with a specific volume (Vt) was placed inside the container. The rest of the empty space was filled with rapeseed. The cake was then removed from the container and the volume of recorded rapeseed (Vs) and the volume of cake came was obtained from (Vt-Vs).

5. **Cake texture evaluation**: According to Ronda et al., (Ronda F et al, 2005) cake tissue evaluation was performed at 2 hours and 2 weeks after baking using a Brookfield texture analyzer, connected to a computer using the Texturepro CTV 1.2 Build 9 software. For this purpose, the entire sample was first prepared in the form of cubic cubes in the dimensions 40x40x20 mm and their crust was then removed. In the next step, the samples were tested under a 25000 TPA probe made from acrylic chlorinate with a diameter of 50.8 and a length of 20 mm. During this test, the speed of the probe was considered to be 1 mm / s, the compression distance (5 mm) and the starting threshold of 50 N (Ronda F et al, 2005). This test was performed on production day and 14 days after sample storage.
6. **Evaluation of cake shell color**: The color analysis of the cake shell was carried out at a time interval of 2 hours after baking through determining three indices L *, a * and b *. L * denotes the lightness of the sample and its range varies from zero (pure black) to 100 (pure white) (Fig. 2-2 b). a * index denotes the closeness of sample color to red to green colors and its range varies from -120 (pure green) to 120+ (pure red) (Fig. 2-3 C). b * parameter denotes the closeness of sample color to the blue and yellow colors, whose range varies from 120 (pure blue) to +120 (pure yellow) (Fig. 1). The surface of the cake shell color was compared using Hanterleb machine and the above mentioned parameters were measured (Sun D, 2008).
7. **Evaluation of Cake Brain Porosity**: A processing technique was used to evaluate the porosity of the cake's brain within 2 hours of baking. For this purpose, a cake slice of 2 in 2 centimeters was prepared and imaged by a scanner (HP Scanjet G3010 model) with a resolution of 1200 pixels (Fig. 2). The image was processed by Image J software. By activating the 8-bit segment, gray level images were built. To convert the gray images to binary images, the binary part of the software was activated. These images are a collection of bright and dark points (Fig. 2) that calculate the ratio of bright to dark points as an indicator of the porosity in the samples. It is obvious that the higher this ratio, the larger the cavities in cake texture (porosity). In practice, by activating the Analysis section of the software, this ratio was calculated and the porosity percentage of the samples was also measured (Haralick RM et al, 1973).

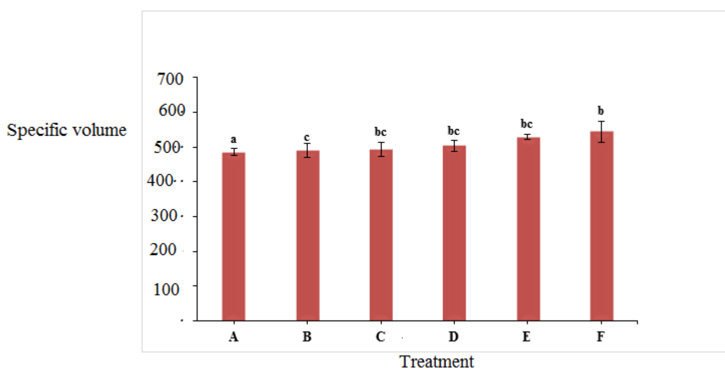
Sensory evaluation: To assess the quality of breads, 10 male and female students were selected from the Faculty of Agricultural Sciences and Natural Resources of Gorgan as panelists. After explaining the study, the table of sensory characteristics of the cake in terms of form and shape (asymmetric shape, tearing or loss of part of the cake and the presence of any cavity or empty space), high-level characteristics (burning, abnormal color, wrinkles and abnormal levels), low level characteristics (burning, wrinkles and abnormal levels), porosity (abnormal porosity, high density and compression), hardness (firmness) and softness of the texture (abnormal softness or dough, firmness and brittleness of cake), chew-ability (dryness and hardness, bullet holes and dough property of cake in the mouth and sticky to the teeth) and odor, flavor and taste (nasty taste and unpleasant odor , raw smell or rancidity and natural fragrance of cake) were completed by the students. The traits evaluation coefficient was rated very bad (1) to very good (5). 50 grams of each cake were given to people in vitro and they drank water at the intervals of each treatment.

Data analysis

Cake specific volume:

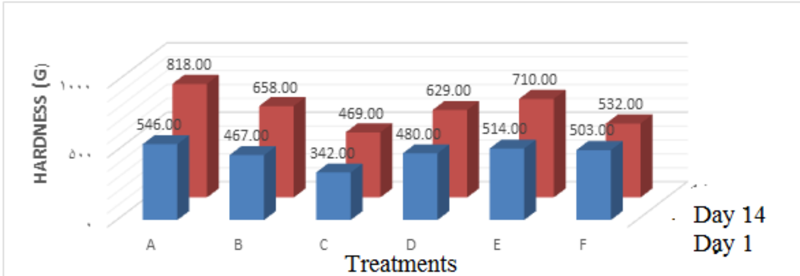
As can be seen in Fig. 1, the difference between the means is due to differences among treatments A, B, F and among these treatments with similar treatments C, D, E, indicating a significant difference between treatments at 0.05 level and by increasing the amount of gum and emulsifiers, the cake volume will be increased as well.

Figure 1. The effect of mixing ratio of gum and emulsifier on specific volume of sponge cake



Texture analysis: As shown in Fig. 2, by increasing the amount of gum and emulsifier, the hardness of the samples was found to decrease, as well as it seems that the hardness of all treatments was found to be higher on the 14 days than the first day.

Figure 2. Comparison of hardness in day 1 and day 14



Crust colorimetric parameters (L *, a * and b *):

As can be seen in Table 3, since all treatments in parameters of L * and a * are represented with a letter, the difference between the means is not statistically significant. The results indicate that the difference between the means is related to the b * parameter in terms of Duncan's letters.

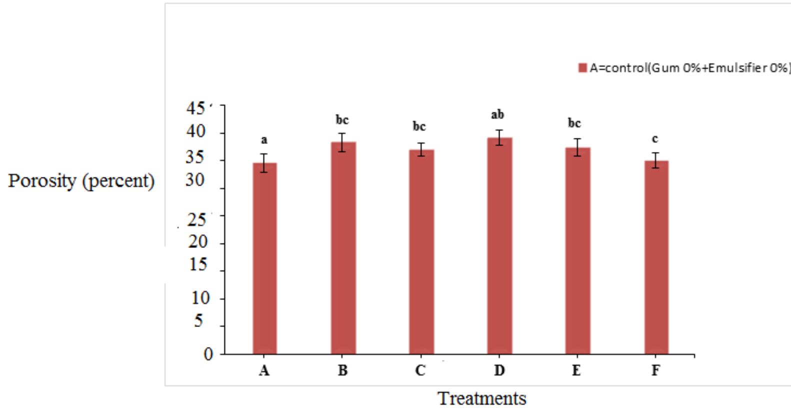
Table 3. Effect of mixing ratio of gum and emulsifier on the amount of L *, a * and * b parameters in sponge cake

The lower case letters in each row represent insignificance at 0.05 level.

Treatment	Cake L * Parameter	Cake a * Parameter	Cake b * Parameter
A. Control (0% gum, 0% emulsifier)	41/6123±0/47853[a]	14/7742±0/5426[a]	36/1673±1/14325[ac]
B (0% gum, 0.5% emulsifier)	41/5823±0/2936[a]	14/5069±0/48705[a]	35/3003±1/40475[c]
C (0.3% gum, 0% emulsifier)	43/8023±0/20659[a]	14/9892±0/58676[a]	41/2033±1/60601[a]
D (0.3% gum, 0.5% emulsifier)	43/9956±0/46852[a]	14/1543±0/865[a]	38/28±2/59299[ab]
E (0.5% gum, 0% emulsifier)	42/6489±0/14901[a]	14/9747±0/5967[a]	36/7636±1/62854[bc]
F (0.5% gum, 0.5% emulsifier)	42/6156±0/08479[a]	13/2520±1/12741[a]	36/3131±2/05325[bc]

Cake Porosity: As can be seen in Figure 3, Duncan's test shows that the difference between the means is due to the difference between the control treatments of A, D, F and the similar treatments of B, C, E and with increasing the amount of gum and emulsifier, the cake porosity has been increased as well.

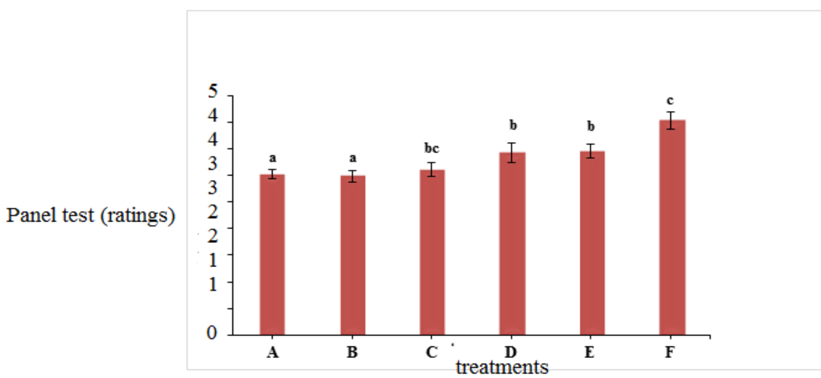
Figure. 3 Effect of mixing ratio of gum and emulsifier on porosity of sponge cake



Cake Panel Test:

As you can see in Figure 4, there is a significant difference between treatments. The results showed that there is a significant difference at the level of 0.05 between treatments in terms of cake panel test and the highest sensory rating is related to C treatment.

Figure 4: The effect of mixing ratio of gum and emulsifier on the sensory rating of sponge cake



Discussion and Conclusion:

8. The results of analysis of variance (ANOVA) and Figure 1 indicated that there is a significant difference at the level of 0.05 between treatments in terms of specific cake volume. Comparison of the mean of specific cake volume in the treatments showed that the highest amount of specific cake volume was related to treatment F

(0.5% gum and 0.5% emulsifier) and the lowest amount of specific cake volume to treatment A (0% gum) and 0.0% emulsifier). The reason for an increase in the specific cake volume can be due to its specific structure of gums which are able to enhance the gluten network by stirring and mixing the raw material to keep the air bubbles. The results of a study by Naghipour *et al.*, (Naghipour F et al, 2012) indicated that guar and xanthan gums improve the cake volume. In addition, the results of Garlin's (Garlin GT, 2008) study on the effect of emulsifiers showed that emulsifiers are able to expand the cake volume. In a similar study on the impacts of gum and emulsifiers on the quality of cakes, Collarc (Collarc P, 2005) found that guar and xanthan gums increased the final volume of cakes. The results of texture analysis testing revealed that the addition of gum and emulsifiers reduces hardness in all treatments on the first day, which the highest reduction was related to treatment C (0.3% gum and 0% emulsifier) and the highest hardness to sample A (0% gum and 0% emulsifier). It was also found that in all treatments, hardness was found to be increased with time and was decreased compared to the control sample. The results of this study are consistent with those of research by Rosell, Rojas and Bandito (Rosell, CM et al, 2001). Comparison of the mean of treatments in terms of the L * parameter shows that the amount of this parameter was increased when the amount of gum and emulsifier was increased. Furthermore, the findings of the research by Naghipour *et al.*, (Naghipour F et al, 2012) were also consistent with those of the research based on the fact that guar and xanthan gums could make crust cake yellowish and bright. However, the results of analysis of variance showed that there is no significant difference at the level of 0.05 between treatments in terms of L * and a * cake parameters. Meanwhile, there is a significant difference between the treatments in the b * parameter and an increase in the amount of gum and emulsifier could decrease the amount of a * parameter as well. Comparison of mean L * cake parameter among treatments showed that the highest L * cake parameter belonged to treatment D (0.3% gum and 0.5% emulsifier) with an average of 43.99. Also, the lowest L * cake parameter was related to treatment B with a mean of 41/58. The highest a * cake parameter belonged to treatment E with an average of 14.97 and the lowest a * cake parameter was related to treatment F with a mean of 13/25 (0.5% gum and 0.5% emulsifier). The highest b * cake parameter belonged to treatment C with an average of 41.20 (0.3% gum and 0% emulsifier) and the lowest b * cake parameter was related to treatment B with a mean of 35/30. The findings of this study also showed that there is a significant difference between treatments in terms of porous cake. The comparison of the average porosity of the cake among the treatments revealed that the highest porosity belonged to treatment D (0.3% gum and 0.5% emulsifier) and the lowest porosity of cake related to treatment A (control). The reason is that by increasing the amount of water absorption, the agar prevents the formation of dense texture in the cake, thus increasing the porosity in the cake. Maleki *et al.*, (Maleki G et al, 2012) showed that four different hydrocolloids, including guar, xanthan, carboxy propyl methyl cellulose and HPMC produce porous texture in bread. The results showed that there was a significant difference at the level of 0.05 between treatments in terms of cake panel test. Comparison of the cake panel test results among the treatments revealed that the highest score of the cake panel test belonged to treatment F (0.5% gum and 0.5% emulsifier) with a mean score of 4.03. The lowest score for the cake panel test was also related to treatment B (0% gum and 0.5% emulsifier) with mean score of 2.99. The purpose of this study was to investigate the impact of agar and emulsifier gum of propylene glycol monoesterates on physical, sensory properties and overall acceptability factor of the cake. According to the results, F sample (0.5% gum + 0.5% emulsifier) obtained the highest specific volume and sensory scores in the texture test. Based on the results of the study, it is recommended to investigate the use of other gums and emulsifiers with different ratios, the synergistic effect of gums on their individual application, as well as the effects of indigenous gum, such as Shahi gum, Balango Shirazi, Alyssum, and basil in production of sponge cake compared with gum in future research.

Acknowledgement

This study was conducted in the form of a special problem using microbiology lab facilities and Islamic Azad University of Amol and Biotechnology Research Centre, Islamic Azad University of Tabriz.

References:

1. Galic, K., Curic, D. and Gabric, D. (2009). Shelf Life of Packaged Bakery Goods. A review, Critical Reviews in Food Science and Nutrition, 49:5, 405-426.
2. Fathi, M. Salehi, A., (2011). The Effect of additive of emulsifiers and gum on qualitative, rheological and microstructural properties of an egg-free cake, National Conference on Food Industries, No. 10, pp. 4-17.
3. Cauvain, S. P. and Benjamin, C. (2003). Encyclopedia of Food Sciences and Nutrition, Academic Press, 751-759.
4. Peighambardoost. (2007). Biscuit production, cookies and crackers. First volume. First edition of Iran book publication (IJEI), Tehran.
5. Matheis, G., and Whitaker, J.R.A. (1987). Review: Enzymatic cross-linking of properties applicable to foods. Journal of Food Biochemistry, 11: 309-327.
6. Korg, N. (1977). Functions of emulsifiers in food systems. Journal of American Oil Chemists' Society, 5493: 124-131.
7. Gerrard JA, Fayle SE, Wilson AJ, Newberry MP, Ross M, and Kavale S, (1998). The effect of microbial transglutaminase on dough properties and crumb strength of white pan bread. Journal of Food Science, 63: 472- 475.
8. McKenna B.M. (2003). Texture in food. New York: CRC Press.

9. Fatemi, Hassan, (1999). Food Chemistry, First Edition, Publication of the Public Joint Stock Company, pp. 49-60.
10. Maleki, G., Mohammadzadeh Milani, J. (2012). Effect of guar, xanthan, Carboxymethyl cellulose and hydroxypropyl methylcellulose on staling of Barbarie bread, Journal of Research and Innovation in Food Science and Technology, Vol. 1, No. 1, 1-10.
11. Pourfarzad, A., Haddad Khodaparast, M. Kh., Karimi, M., Mortazavi, S.A. (2011). Application of response surface methodology to investigate the effect of gel component on batter of Barbarie bread. Journal of Food Industry Research. Vol. 21, No. 2
12. Arabshirazi, Sh., Movahhed, S., and Nemati. N. (2011). Study of Additional Xanthan and Hydroxy Propyl Methyl Cellulose Gums on Stailing and Sensory Properties of Eggless Cakes. Food Processing and Production.Vol.1, No.2.
13. Ashwini, A., Jyotsna, R., and Indrani, D. (2009). Effect of hudrocolloids and emulsifiers on the rheological characrteristic and quality of flat bread. Lebensm.Wiss.u.Technology, 36: 18-193.
14. Garlin, G.T., (2008). Microscopic study OF cake batters, Cereal chem 21:189-199.
15. Collarc, P., (2005), Effect of water and hydrocolloid, Food Hydrocolloid, 13:467-475.
16. Walker, C. E. (2004). Food applications of sucrose esters, Cereal Food World 29:286.
17. AACC. (2000). Approved Methods of the American Association of Cereal Chemists, 10th Ed., Vol. 2. American Association of Cereal Chemists, St. Paul, MN.
18. Ronda, F., Gomes, M., Blanco, C. A., and Caballero, P. A. (2005). Effects of polyols and nondigestible oligosaccharides on the quality of sugar free sponge cakes. Journal of Food Chemistry, 90: 549-55.
19. Sun, D. (2008). Computer vision technology for food quality evaluation. Academic Press, New York.
20. Haralick, R. M., K. Shanmugam., and Dinstein, I. (1973). Textural features for image classification. IEEE Transactions of ASAE, 45(6): 1995-2005.
21. Naghipour, F, Habibi Najafi, M. B., Karimi, M., Haddad Khodaparast, M. H., Sheikholeslami, Z. Saharan, b. U. (2012). Production of gluten free cake utilizing sorghum flour, guar and xanthan gums. Proceedings of the first national conference on biotechnology, biochemistry and bioengineering, May 20-22. Yazd.
22. Rosell, C. M., Rojas, J. A. and Benedito, B.D. (2001). Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocolloids, 15: 75-81.